CLAIMS

What is claimed is:

1. A high temperature heap bioleaching process for extracting copper from hypogenic copper sulfide bearing ores, the process comprising the steps of:

a. constructing a heap comprising hypogenic copper sulfide bearing ore, said heap including exposed sulfide mineral particles at least 25 weight % of which comprise hypogenic copper sulfides, wherein the concentration of exposed sulfide mineral particles in said heap is such that said heap contains at least 10 Kg of exposed sulfide sulfur per tonne of solids in said heap, and wherein at least 50% of the total copper in said heap is in the form of hypogenic copper sulfides;

b. heating a substantial portion of said heap to a temperature of at least 50°C;

c. inoculating said heap with a culture comprising at least one thermophilic microorganism that biooxidizes sulfide minerals at a temperature above 50°C;

d. irrigating said heap with a process leach solution comprising sulfuric acid and ferric iron;

e. bioleaching sufficient sulfide mineral particles in said heap to oxidize at least 10 Kg of sulfide sulfur per tonne of solids in said heap and to cause the dissolution of at least 50% of the copper in said heap into said process leach solution within a period of about 210 days or less from completion of said heap; and

f. collecting pregnant process leach solution that contains dissolved

copper as it drains from said heap.

2. A process according to claim 1, wherein said heap includes at least 30 Kg of sulfide sulfur per tonne of solids in said heap.

3. A process according to claim 2, comprising bioleaching sufficient sulfide mineral particles in said heap to oxidize at least 30 Kg of sulfide sulfur per tonne of solids in said heap in a period of about 210 days or less.

4. A process according to claim 1 or 3, comprising bioleaching sufficient sulfide mineral particles in said heap to cause the dissolution of at least 70% of the copper in said heap into said process leach solution in about 210 days or less.

5. A process according to claim 1 or 3, comprising bioleaching sufficient sulfide mineral particles in said heap to cause the dissolution of at least 80% of the copper in said heap into said process leach solution in a period of about 100 days or less.

6. A process according to claim 1, wherein said substantial portion of said heap is heated to a temperature of at least 60°C.

7. A process according to claim 1, wherein said substantial portion of said heap is heated to a temperature of at least 70°C.

8. A process according to claim 1, wherein said culture comprises a mixed

culture including a plurality of different thermophilic microorganisms that biooxidize sulfide minerals at a temperature above 60°C.

9. A process according to claim 8, wherein said culture comprises a mixed culture including a plurality of different thermophilic Archaea that biooxidize sulfide minerals at a temperature above 60°C.

10. A process according to claim 1, wherein said heap is constructed by a process comprising the steps of:

a. coating the surface of a plurality of coarse substrates having a particle size of greater than about 0.3 cm and less than about 2.54 cm with a sulfide mineral concentrate comprising hypogenic copper sulfides and having a particle size less than about 250 μm; and

b. stacking said plurality of coated coarse substrates into a pile to form said heap.

11. A process according to claim 10, wherein said plurality of coarse substrates are comprised of at least one material selected from the group consisting of rock, brick, slag, and plastic.

12. A process according to claim 11, wherein said plurality of coarse substrates comprises rock selected from the group consisting of lava rock, barren rock, and crushed copper ore.

13. A process according to claim 10, 11 or 12 wherein the amount of concentrate coated onto said plurality of coarse substrates is from approximately 9% to 30% of the combined weight of said concentrate and said coarse substrates.

14. A process according to claim 13, wherein said concentrate further comprises at least one readily oxidizeable sulfide mineral.

15. A process according to claim 14, wherein said at least one readily oxidizeable sulfide mineral comprise at least one sulfide mineral from the group consisting of pyrite, arsenopyrite, covellite, and chalcocite.

16. A process according to claim 14, wherein the amount of sulfide sulfur from said at least one readily oxidizeable sulfide mineral is at least about 10 Kg per tonne of solids in the heap and the amount of sulfide sulfur from said hypogenic copper sulfides is at least about 10 Kg per tonne of solids in the heap.

17. A process according to claim 15, wherein the amount of sulfide sulfur from said at least one readily oxidizeable sulfide mineral is at least about 10 Kg per tonne of solids in the heap and the amount of sulfide sulfur from said hypogenic copper sulfides is at least about 10 Kg per tonne of solids in the heap.

18. A process according to claim 16, wherein said substantial portion of said heap is heated to a temperature of 50°C in a period of approximately 45 days or less and at least a portion of the heat required to heat said heap is supplied by bioleaching at least

10 Kg of sulfide sulfur per tonne of solids in said heap.

19. A process according to claim 17, wherein said substantial portion of said heap is heated to a temperature of 50°C in a period of approximately 45 days or less and at least a portion of the heat required to heat said heap is supplied by bioleaching at least 10 Kg of sulfide sulfur per tonne of solids in said heap.

20. A process according to claim 1, wherein said process leach solution further comprises chloride ions.

21. A process according to claim 1, further comprising an insulating barrier layer covering said heap.

22. A process according to claim 21, wherein said insulating barrier layer is selected from the group consisting of a tarp, a layer of fiberglass insulation, a layer of plastic sheet, and a layer of crushed rock.

23. A process according to claim 1, wherein said hypogenic copper sulfides comprise at least one hypogenic copper sulfide selected from the group consisting of bornite, enargite, tetrahedrite, and tennatite.

24. A process according to claim 10, wherein said hypogenic copper sulfides comprise at least one hypogenic copper sulfide selected from the group consisting of bornite, enargite, tetrahedrite, and tennatite.

25. A process according to claim 1, wherein said hypogenic copper sulfides comprise chalcopyrite and at least one additional hypogenic copper sulfide mineral.

26. A process according to claim 10, wherein said hypogenic copper sulfides comprise chalcopyrite and at least one additional hypogenic copper sulfide mineral.

27. A high temperature heap bioleaching process for the recovery of copper from hypogenic copper sulfide bearing ore, the process comprising the steps of:

a. constructing a heap comprising hypogenic copper sulfide bearing ores, said heap including exposed sulfide mineral particles at least 25 weight % of which comprise hypogenic copper sulfides, wherein the concentration of exposed sulfide minerals in said heap is such that said heap contains at least 10 Kg of sulfide sulfur per tonne of solids in said heap, and wherein at least 50% of the total copper in said heap is in the form of hypogenic copper sulfides;

b. heating at least 50% of said heap to a temperature of at least 60°C;

c. maintaining at least 50% of said heap at a termperature of at least 60°C until at least 50% of the copper in said heap is dissolved;

d. inoculating said heap with a culture comprising at least one thermophilic microorganism that bioleaches sulfide minerals at a temperature above 60°C;

e. irrigating said heap with a process leach solution at a rate of at least 72 liters/m^2/day;

f. bioleaching sulfide mineral particles in said heap to thereby cause the

dissolution of the sulfide mineral particles and generate heat, wherein sufficient sulfide minerals are oxidized in a bioleaching period of 210 days or less to oxidize at least 10 Kg of sulfide sulfur per tonne of solids in said heap and cause the dissolution of at least 50% of the copper in said heap into said process leach solution;

g. collecting a pregnant process leach solution that includes copper cations from said heap during said bioleaching period; and

h. recovering copper from said pregnant process leach solution.

28. A process according to claim 27, wherein said pregnant process leach solution contains at least 2 g/l copper.

29. A process according to claim 27, wherein said pregnant process leach solution contains at least 5 g/l copper.

30. A process according to claim 27, wherein copper is recovered from said pregnant process leach solution by a process selected from the group consisting of solvent extraction, ion exchange, and copper cementation.

31. A process according to claim 27, wherein copper is recovered from said pregnant process leach solution by solvent extraction.

32. A process according to claim 27, wherein said heap further comprises an insulating barrier layer on its surface.

33. A process according to claim 27, wherein said heap is heated by flowing at least one heat source selected from the group consisting of steam, heated air, and heated aqueous solution through said heap.

34. A process according to claim 27, wherein said heap is heated to 60°C with heat generated from bioleaching a portion of said sulfide mineral particles in said heap with at least one microorganism selected from the group consisting of mesophiles and moderate thermophiles.

35. A process according to claim 33 or 34, wherein at least 50% of said heap is heated to 60°C within a period of 30 days.

36. A process according to claim 27, further comprising the step of passing said collected pregnant process leach solution and said process leach solution through a heat exchanger to transfer heat from said pregnant process leach solution to said process leach solution.

37. A process according to claim 27, wherein the heat generated by bioleaching is sufficient to maintain at least 50% of said heap at said temperature.

38. A process according to claim 27, wherein said hypogenic copper sulfides comprise of at least one hypogenic copper sulfide selected from the group consisting of chalcopyrite, bornite, enargite, tetrahedrite, and tennatite.

39. A process according to claim 27, wherein said hypogenic copper sulfides comprise chalcopyrite and at least one additional hypogenic copper sulfide mineral.